

Title: **CIRCUIT BOARD**

### **Field Of The Invention**

This invention relates to electrical circuit devices comprising porcelain enameled coated metal substrates such as printed circuit boards wherein conductive patterns are applied to the surfaces of the porcelain enameled coated metal substrates. In particular, the invention relates to forming high strength solder connections between a flexible conductor, for example, a wire or the lead of an electronic component and the printed circuit boards formed of porcelain enamel coated metal substrates. The invention also relates to the devices formed in accordance with the methods of the invention.

### **Background Of The Invention**

Many modern printed circuit cards comprise substrates formed of porcelain enameled metal. Circuits are formed on the substrates using conductive, dielectric or other resistive materials.

The resulting coated metal substrate can be used for circuit boards, thermal sinks, thermal barriers, RF shielding, magnetic flux conduction, mechanical attachments and other related applications. Such coated metal substrates that are coated with a porcelain enameled material are commonly referred to as porcelain enameled metal substrates (PEMS).

Discrete circuit patterns can be formed on the PEMS by conventional techniques such as screen printing, firing, etc. The circuit patterns can serve as switch contacts, circuit traces to carry current, and terminals for interconnection of external wires. The circuit patterns may be formed on one or both sides of the substrate.

In the prior art, in order to attach a wire or other conductor such as a lead to the circuit formed on the PEMS, an aperture would be created in the substrate, the wire or conductor would then be inserted into the aperture, and the wire or conductor would be soldered to the electrical circuit. Alternatively, the wire or lead was soldered to a pad formed by thick film material on the surface of the substrate. However, these conventional soldering techniques resulted in weak joints. The weakness of the solder joint at the connection is a very common problem. Typically the strength of the solder joint on these electrical circuit devices are less than half the pull strength of similar solder joints on electrical circuit devices comprised of, for example, alumina ceramic. Thus, a need exists for a method to secure conductors to a PEMS that provides high mechanical strength and durability as well as good electrical conductivity.

#### **Summary Of The Invention**

In view of the aforementioned needs, the invention contemplates a durable, high strength interface or connection between a printed circuit board comprised of porcelain enamel coated metal substrates and an external conductor such as a wire or a lead of an external electronic component.

In the method of the present invention, an aperture is first created in the substrate. The aperture is formed in a manner to ensure that the metal substrate is electrically insulated from the aperture. Then, an eyelet is inserted into the aperture. The eyelet is usually crimped, but other means are available that will cause the eyelet to be mechanically retained in the aperture and form an electrical connection between the eyelet and circuitry formed on the surface of the printed circuit board. A conductor is then inserted into the eyelet and then soldered to the eyelet such that the thick film adjoins the eyelet. The addition of an eyelet to the soldered joint connection mechanically reinforces the solder joint and provides unexpected vastly improved mechanical strength to the joint.

Among those benefits and improvements that have been disclosed, other objects and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings. The drawings constitute a part of this specification and include exemplary embodiments of the present invention and illustrate various objects and features thereof.

### **Brief Description Of The Drawings**

Figure 1 shows a top view of a circuit board embodiment according to the present invention;

Figure 1A shows a top view of the circuit board of Figure 1 with the leads mounted to the board;

Figure 1B is a schematic broken-away cross-sectional view of a portion of a circuit board made in accordance with the present invention;

Figure 2 shows a schematic broken-away cross-sectional view taken showing a portion of a circuit board made in accordance with the present invention wherein the metal substrate is electrically insulated from the hollow mechanical fastener;

Figure 3 shows a cross-sectional view of an embodiment according to the present invention wherein the metal substrate is in electrical contact with the hollow mechanical fastener; and

Figure 4 shows a cross-sectional view of a embodiment of the invention wherein the metal substrate is electrically insulated from the hollow mechanical fastener.

### **Detailed Description Of The Invention**

Referring more particularly to the drawings and initially to Figures 1, 1A and 1B, there is shown a portion of an electrical circuit device 10 having a conductive and supportive metal substrate or base 11. In a preferred embodiment, base 11 comprises a steel substrate coated along the top 12 and bottom 13 surfaces with porcelain enamel 14. In each of the drawings 1-4, the same reference

numerals have been utilized to identify similar elements. The porcelain enamel coated steel substrates are commercially available from the ECA Electronics Company located in Erie, Pa. In addition to a porcelain enameled steel substrate, it will be appreciated that base 11 may comprise any number of other conventional metal substrate materials such as, for example, low carbon steel, stainless steel or aluminum.

Device 10 include conductive circuit patterns 16 formed on at least one surface of the dielectric material or enamel 14. Methods for forming the circuit patterns on the substrate are well known to those skilled in the art, such as screen printing, firing, etc. See U.S. Patent No. 5,605,715 issued to Giardina, et al. or U.S. Patent No. 5,554,965 issued to Sundberg which applicant hereby incorporates by reference for additional examples of methods used for forming circuit patterns on porcelain enameled metal substrates. The methods for forming the conductive circuit patterns on dielectric materials such as porcelain enamel are well-known in the art, and are not limited to those methods specifically disclosed herein.

Referring once again to Figure 1B an aperture 17 is created in the base 11 and the enamel 14 in order for an external conductor to be connected to the circuit device 10. A hollow mechanical fastener, normally a metal eyelet 20, is then inserted into the aperture. A typical eyelet suitable for use with this invention is sold by Keystone Electronics Corp, 31-07 20th Road, Astoria, NY 11105. Eyelets are available in a variety of sizes so as to accommodate a variety of aperture opening sizes and lead sizes. Eyelets that are pre-scored, that is grooves are placed in the eyelet for easy separation upon crimping, are also available. Pre-scored eyelets are available commercially from Mark Eyelet and Stamping, 63 Wakelee Road, Wolcot, Conn. Similarly, "solder through" eyelets, that is special eyelets which utilize capillary action to carry molten solder from the bottom side of a printed circuit board eyelet in a single operation are commercially available. These fasteners or eyelets are

Conn. Similarly, "solder through" eyelets, that is special eyelets which utilize capillary action to carry molten solder from the bottom side of a printed circuit board eyelet in a single operation are commercially available. Fasteners are available in a variety of materials, for example, brass, aluminum, steel and copper.

5           Since the typical hollow mechanical fastener or eyelet is comprised of metal, means to electrically insulate the steel substrate **11** from the eyelet **20** are necessary to prevent the eyelet from short circuiting the circuit patterns **16** to the substrate **11**. As illustrated in Figure 2, one method of doing this is by coating or covering walls of the opening **17** of the steel substrate **11** with the dielectric enamel material **15**. As shown in Figure 3, in applications where it may be desirable not to electrically isolate the fastener **20** from the base **11**, the base **11** can be allowed to contact or engage the fastener **20**. A further alternative embodiment is illustrated in Figure 4, wherein the steel substrate **11** is insulated from the aperture **20** by a nonconductive sleeve **25**. Such sleeve **25** is formed of a flexible material such as silicone or an elastomer.

10           The hollow mechanical fastener **20** is preferably mechanically fastened to the electrical circuit device **10**. The method of fastening is dependent on the type of fastener used. The typical eyelet is flanged on one end **30** and then inserted into the hole or aperture **17**. The opposite end **34** of the eyelet is then crimped, causing the eyelet to deform by forcing the metal to expand, forming an annular ring which is larger than the hole **17** and the annular ring is compressed against the circuit pattern **16**, making mechanical contact with the surface of the board, thereby mechanically holding  
15           the eyelet in place and preventing the eyelet from sliding back through the hole **17**. However, several other methods of mounting are available such as soldering, threading the opposite end of the fastener and utilizing a nut, insertion of a sleeve inside the hollow metallic fastener with a flanged end that  
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is secured with clips, retaining pins, or a compression fitting. As there are many different methods known to those skilled in the art, this list is meant to be illustrative, not exhaustive or exclusive.

Once eyelet **20** is mounted, a (metal wire such as a conventional flexible copper wire) metal conductor **50** is then inserted inside the eyelet **20**. Solder **52** is then applied to the joint to form a permanent mechanical and electrical connection. In the preferred embodiment, additional solder **52** is applied so that the conductor **50**, eyelet **20**, and conductive circuit **16** are all permanently electrically and mechanically connected on the electrical circuit device **10** as shown in Figure 2. If desired, the conductor **50** may also be soldered to the opposite surface of the eyelet **20**, or similarly to the eyelet on the opposite surface of the circuit device **10** and any circuitry on that side. This invention does not contemplate that a specific surface on the electric circuit device must be used, any or all surfaces may be used.

Although the invention has been shown and described with respect to preferred embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon reading and understanding the specification. The present invention includes all such equivalent alterations and modifications, and is limited only by the scope of the following claims.